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COGNITIVE FACTORS IN GROSS MOTOR SKILL

by

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The undersigned certify that they have read,
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ABSTRACT

It is generally agreed that cognitive processes are involved in performance of most educationally and industrially relevant motor tasks (Bartlett, 1958). Relationships between the more pervasive cognitive functions and gross motor performance have been inadequately explored. On the assumption that such relationships exist, the purpose of the present investigation was to determine whether selected measures of personality traits and of perceptual and intellectual abilities would differentiate performers who were highly proficient in one or other of two discrete skill classes.

Thirty-two male and twenty-eight female intercollegiate athletes were grouped according to the nature of cognitive demand inherent in the activity in which each participated. Tennis, badminton, and fencing were classed as complex open skills, complexity referring to the degree of variability of stimulus input and of response, and openness to the dual source (proprioceptive and environmental) of critical stimuli.

A simple closed skill designation was applied to sprint running and sprint swimming in which critical stimuli are largely proprioceptive and redundant.

The complex open skill group was found to be significantly higher in traits of introversion ($p < .01$), and intuition, ($p < .01$), and the simple closed skill group significantly higher in opposite traits of extraversion $p < .01$, and sensing, $p < .05$, when scores on the Myers-Briggs Type Indicator were compared. Mean scores on the Cattell Culture Fair Test of Intelligence and on tests of speed and flexibility of perceptual closure did not differ significantly for the two groups. Implications for research and for educational and industrial practice were discussed.

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CHAPTER I

INTRODUCTION

Background

Human motor behavior has become better understood due to research done by scientists representing a number of disciplines and a variety of interdisciplinary spheres of interest. Traditionally, medical scientists and physical educators have approached questions of motor performance through analysis of the physical properties of motor acts in relation to anatomical and physiological variables, though they, like the social scientists, have also studied movement as a medium of communication. Developmental psychologists have postulated the relevance of sensory-motor experience not only to physical development but to the development of cognitive structures and abilities (Flavell, 1963). The effects of a wide range of stimuli on motor performance have been demonstrated by experimental psychologists while educational psychologists have contributed to the understanding of motor learning. Applied psychologists working in military and industrial settings have extended the analysis of motor skill and have put certain theoretical propositions and

laboratory findings to large scale empirical test (Vernon, 1949).

Although considerable inter- and intra-disciplinary overlapping is evident with respect to investigations of motor behavior, it would appear that this applies more to investigations of fine than of gross motor skill (Cratty, 1964). Conclusions derived from experiments in performance of motor tasks involving solely the smaller localized muscle groups, have been somewhat indiscriminantly applied to problems of gross motor learning and performance (Cratty, 1964), and the relationship is yet far from clear. Possibly automation has reduced the interest of industrial scientists, and to some extent lessened the concern of military personnel, with problems of gross skill; at the same time it has augmented research efforts among medical scientists and physical educators and within the latter group there appears a growing interest in the cognitive aspects of gross motor behavior (Cratty, 1964).

I. NEED FOR THE STUDY

To quote Cratty (1964, p. 21):

While helpful in the past, the traditional approach of the kinesiologist no longer seems to offer a complete explanation of variations

in human movement. Describing man as a system of bony levers moved by muscles and undergirded by various physiological systems seems to place little emphasis upon individual performance differences.

Smith and Smith (1962, p. 1) are of the opinion that:

. . . with all the detailed knowledge of sensory, neural, and motor systems, there has never been a satisfactory account of how patterned motion is regulated.

When motor performance is regarded as purposeful, goal-centred behavior and when skill denotes performance of reasonable complexity, it is evident that central neural processes are involved in mediating the stimulus-response connection (Bartlett, 1958; Osgood, 1964). The cognitive aspects of gross motor skill have been largely overlooked by researchers, but more particularly it is the contribution of cognitive factors to individual differences in performance that have remained unexplored. The most striking evidence of this lack of research--or at least the lack of application of existing knowledge to movement problems, is the discovery that multiple measures of physiological characteristics have repeatedly failed as predictors of performance criteria. (McCraw, 1949; Olsen, 1956; Parker and Fleishman, 1960). The conclusion reached by a number of investigators (Bachman, 1961; Henry, 1958) has been that abilities are highly

specific to the task involved, however, this generalization has been lately questioned by one writer who proposes the existence of basic as well as specific factors (Cratty, 1964). The present thesis is intended as a contribution to knowledge in this area.

III. THEORETICAL DISCUSSION

A number of systems have been devised for the classification of motor skills (Wenger, 1951). Most are based on such physical properties as repetition, load, fixation, and direction, but have not been elaborated to include consideration of the source and nature of stimulus input. An exception is Poulton's (1960) classification which designates an open skill as one in which critical stimuli impinge from environmental as well as from internal sources, and a closed skill as one in which stimulus input is almost exclusively proprioceptive. Poulton points out that the source of stimulus input relates to the nature of predictions demanded of the performer, but it would appear that the degree of variability of stimuli is an equally important consideration in prediction. The writer suggests that a skill moves up a continuum of complexity with increasing variability

in stimulus input together with increasing freedom of the performer to respond in variant ways to any one stimulus cue.

The operation of decision processes is implied in the view that stimulus cues must be interpreted by the performer (Bruner, 1957). If motor response is facilitated by anticipation (Poulton, 1960; Bartlett, 1958), the performer must maintain a state of readiness for critical cues which may appear in the stimulus sequence. According to Bruner, perceptual readiness depends upon accessibility of categories to which cues may be assimilated. Accessibility depends in turn on the frequency with which instances of a given category occur; that is, upon their probability of occurrence, and upon the needs and purposes of the performer in terms of his intent. It would seem to follow that the lower the probability of occurrence of any one cue and the greater the number of response alternatives to that cue, the greater is cognitive demand in terms of the complexity of decision processes. Bruner also points out that as the number of critical stimuli in an array increases, the identification threshold for any one stimulus in that array also increases.

In simple closed skills exemplified for the purpose of this thesis by sprint running and sprint swimming, there is one crucial external stimulus (the sound of a pistol) which initiates a serial movement sequence. Uncertainty with respect to this stimulus is minimal, not only because of its constant nature, but also because its occurrence is limited to a narrow time range. Once movement is commenced, virtually all visual, auditory, and other forms of external stimuli become irrelevant and must be gated out. Because the movement sequence is highly practiced and because, when efficient, it requires no amendment, proprioceptive feedback is largely redundant and this further reduces cognitive demand.

In contrast, complex open skills exemplified by tennis, badminton, and fencing, supply a continuous display of external stimuli which are variant in time and space. In addition, amendment is essential for adaptation to changing events hence proprioceptive feedback constitutes a vital source of information. Frequency combined with variability of critical cues clearly increases uncertainty and may necessitate scanning of the display for additional cues which will facilitate categorization. In the case of simple closed skills which have been highly practiced, it may be presumed

that category specification would be in most instances congruent with impinging cues so that probability would be high. If this is so, one would expect a greater dropping out of consciousness in performance of simple closed skills than would be expected in performance of skills of the complex open type (Leonard, 1953).

The writer has proposed that complex open skills offer response alternatives and that selection relates to the performer's strategic intent. In situations where response freedom exists, Bartlett (1958) points out that preceding sensory input does not supply evidence of what the specific response should be. In this case, he says, there is no necessity for direct discrimination of the attributes of an oncoming stimulus item in the sequential supply. All that is necessary is an indication that at some well defined stage in the developing display, there will come a cue which it will be important to treat in a way appropriate to the total strategy. This indication, he adds, is always symbolic in nature.

If, on the basis of the preceding discussion, it may be concluded that simple closed and complex open skills differ markedly with respect to cognitive demand, it appears worthwhile to explore the possibility that proficient performers in each skill class differ with

respect to their generalized preference for dealing with cognitively complex tasks and in their tendency for conscious mediation and attendant abilities for analysis and abstraction./ Admittedly the present investigation is exploratory and speculative for it derives from no discrete theoretical position, nor have the relationships to be hypothesized more than minimal empirical support. Nonetheless there are some findings which seem relevant.

According to Bruner (1957), there is a progressive narrowing of categories in cue utilization as stimuli become more numerous and probabilities less certain. Where stimuli are few and probabilities high, there is a greater openness to sensory input than when perception is selective. Narrow categorizing thus appears to be a necessary determinant of efficient performance in the case of complex open skills. Consistencies have been found in the breadth of categories typically adopted by individuals (Bruner, 1961). Narrow categorizers were more sensitive to changes in the stimulus environment and were more intelligent than broad categorizers who tended toward perseveration in response to changing stimuli.

Goldstein and Scheerer (1941) differentiated individuals characterized by concrete as opposed to conceptual attitudes. The concrete attitude was described as one in which the individual is bound to specific stimuli of a tangible sort and prefers to avoid what is complex and ambiguous. A conceptual attitude is characterized by ability to plan ahead ideationally, to break a given whole into parts, to think symbolically and to detach the ego from the outer world.

Klein (1949a) uses the term perceptual attitude to refer to typical modes of response which cut across adaptive properties of the individual, maintaining that because the perceptual system provides for detection, selection, and control over stimulation, its diversity should be reflected in personality.

Psychologists of the Georgian Academy of Sciences, U.S.S.R., are reported to regard perceptual set as a relational phenomenon which emerges from interaction of organism and environment. In contrast to the view that action follows perception, they maintain that the disposition toward action is imminent in set, and further that the essence of personality is its various sets. In addition to presenting evidence of the generalization of sets and their transfer across sensory modalities,

Georgian researchers have demonstrated relationships between perceptual sets and temperamental characteristics of normal subjects (Miller, 1962).

Because the writer wished to investigate relatively stable cognitive characteristics of athletes but lacked a substantial theory which might have suggested appropriate tests, it seemed advisable to employ conventional measures suggested by the foregoing discussion; namely, measures of intelligence, perceptual abilities, and personality traits. Specific criteria for test selection are described in Chapter IV; however, albeit speculative, the general rationale underlying choice of measures may be stated as follows:

If athletes who are proficient in complex open skills differ from those proficient in simple closed skills with respect to the cognitive strategies they employ while performing, and if these differing strategies are typically applied to a range of non-motor problems, then strategies facilitating solution of such problems may be regarded as abilities and may be measured by paper and pencil tests. More particularly, if athletes proficient in complex open skills are more analytic and more inclined toward cognitively mediated response, they should perceive relationships in figural

intelligence test items more readily than non-analytic subjects especially when inferences must be made on the basis of incomplete information. Similarly, they should do better in performance of perceptual tasks which involve abstraction in visual fields where uncertainty is increased by the imposition of distracting stimuli. If individuals who are proficient in motor skills characterized by high probability and redundancy of stimuli typically utilize decision strategies which do not facilitate adaptation to stimulus change, then this should be reflected in their responses to intelligence test item sequences which require change of strategy. Moreover, if these individuals are motivated to reduce uncertainty by action rather than mediation; that is, if they tolerate risk in preference to delayed response, they might be expected to manifest relatively rapid perceptual closure when faced with ambiguous stimuli.

In the area of personality, Jung (1923) proposes that the extravert attends to what reaches him from external sources while the introvert relies on mental associations evoked by sensory impressions. Extraversion-intraversion may be organized around one of four psychological features: thinking, feeling, sensation, and intuition. The extraverted sensing type is conditioned

to and oriented by sensory and/or concrete features of the environment. Intraverted intuitive types direct attention to imagery and these images organize their activity. Extraverted feeling types tend to feel and act according to expectations about aspects of a situation while intraverted thinking types respond on the basis of ideational patterns which have been subjectively organized. If focusing on the external environment facilitates performance of simple closed skills and if cognitive mediation facilitates efficient motor response in skills of the complex open type, then intraversion-extraversion, sensing-intuition, and thinking-feeling are personality dimensions which, for the present purpose, it seems appropriate to explore.

CHAPTER II

REVIEW OF RELATED RESEARCH

I. PERSONALITY AND MOTOR PERFORMANCE

A number of studies bear on the relationship of intraversion-extraversion to visual motor skill performance and vigilance tasks. Broadbent (1958) found that in a multi-choice serial reaction task more extraverted subjects showed greater deterioration of performance with prolonged work than did more intraverted subjects. Wilkinson (1957) measured reaction times to unexpected signals occurring at rare intervals during a twenty-five minute watch. There was no difference in mean reaction times for intraverted and extraverted subjects, but extraverts showed increasingly less variability in reaction time. Venables (1955) found that normal subjects who had high scores on measures of extraversion performed worse in a mixed sequence multi-choice reaction task than in a simpler two-choice task. When subjects performed a serial reaction task under quiet and noisy conditions, Broadbent, (1954) found that extraverted subjects did relatively worse throughout the experiment if they commenced under

the noisy condition than if they commenced in quiet. In a tactile task, Eysenck (1955) showed that figural after effects were greater in extraverts than in intraverts. The general conclusion Broadbent (1958) draws from these findings is that extraverts respond less well to stress of a perceptually distracting type. This he attributes to the fact that the typical strategy of the extravert involves short term sampling of information which facilitates speed but not accuracy of response, while the intravert employs a long term sampling system causing greater delay in reaction but greater accuracy. In short term sampling system response is guided by the effects of immediately previous experience. Long term systems imply reference to a series of previous performances. Clearly, short term sampling is a superior strategy in tasks of a non-variable nature, but where a task is highly variable deficit can be expected if the individual lacks appropriate response in meeting a changed situation.

Broadbent's conception of long and short term sampling seems consistent with the foregoing discussion (Chapter II) suggesting that extraverts are alerted to the immediate stimulus while intraverts weigh knowledge of past results. Eysenck's (1957, p. 28) summary of empirically established correlates of intraversion and

extraversion offer further support for this view.

II. PERSONALITY DIFFERENCES IN ATHLETES

Studies concerned with the personality traits of university athletes are rare in the literature. Sperling (1942) found differences between athletes and non-athletes but intramural and intercollegiate groups were not differentiated by personality measures. Differences between intercollegiate participants in team and individual sports were consistent but not statistically significant. Personality profiles of athletes participating in team sports of a non-contact nature resembled those of athletes who took part in individual activities. Henry (1941) found weight-lifters to be less ascendant and more neurotic, socially introverted, hypochondriac, neurasthenic, and hypersensitive than students majoring in physical education. Track athletes were less intraverted and hypochondriac than weight-lifters. Comparative studies of non-intercollegiate sports participants include those of Henry (1947) and Flanagan (1950). The latter administered a personality inventory comprised of scales for masculinity-femininity, ascendance-submission intraversion-extraversion and emotional stability-instability to college males who were voluntary participants in fencing, badminton,

basketball, volleyball, boxing, and swimming classes. Among findings relevant to the present study, it was shown that fencers were higher in ascendance than all groups except badminton players, and that fencers and badminton players were significantly more extraverted than volleyball players. Presumably subjects were in earlier stages of learning these skills. Flanagan concluded that personality factors influence the choice of one physical activity course in preference to others. Booth (1951) studied M.M.P.I. profiles of male college subjects classified according to level of competition and level of skill attained. Significant differences existed between athletes and non-athletes and between participants in individual sports and team sports. Certain M.M.P.I. items discriminated between more and less skilled intercollegiate performers but results were not reported by sport grouping.

Reported personality studies of female athletes (Thorpe, 1958; Marler, 1962; Ramsey, 1962) contain little of meaning for the present problem since comparisons involved either mixed sports groups or participants and non-participants in a simple activity. The writer has located no studies which investigated the personality characteristics of highly skilled athletes grouped

according to a classification based on cognitive demand. The literature permits only the conclusion that personality factors play some part in interest and level of skill attained by participants in certain sports activities.

III. INTELLIGENCE AND MOTOR SKILL

Sir Frederick C. Bartlett (1947, p. 880) is of the opinion that:

What is called intelligence; innate general cognitive ability, is the first essential to the acquisition of every form of higher skill. The more complex and varied the skill to be acquired, the higher the intelligence needed to acquire it.

While such statements were not located by the writer in books devoted to the subjects of competitive swimming and sprint running, of badminton Davidson (1953, p. 65) says:

There are two ways in which the brain must work:

1. It must plan an overall strategy to break up the opponent's game but keep the plan flexible so that it can cope with any change made in the opponent's style of play.
2. It must find the answer to each shot within a fraction of a second. So speedily does this happen at times that seemingly more a matter of instinct than of conscious effort starts the racquet forward.

Talbert (1957, p. 23) says of tennis that, as a game of skill, it requires as much thinking and planning as it does stroke production.

Seegers and Postichal (1936) found higher correlations between intelligence quotient and performance in the case of more complex as compared to more simple motor skills. Similarly, Ruch (1925) noted that the relation between intelligence and the performance of certain motor tasks increased with the complexity of tasks. A number of investigations (Start, 1964; Burley and Anderson, 1955) revealed low to negligible correlations between intelligence quotient and performance of simple ballistic skills. Start (1961) found an insignificant relationship between ability ratings in soccer and rugby, intelligence quotient and academic streaming among British schoolboys. In studying university athletes Di Giovanna (1937) demonstrated a curvilinear relationship between sports ability and intelligence, however his design made no provision for classification of skills. Among high school athletic award winners, Reals and Rees (1939) found track athletes significantly higher and baseball players significantly lower in intelligence quotient than other groups, but it may be presumed that within the track group were athletes who specialized in skills of varying complexity. Ray (1940)

reported a correlation of .76 between mental and motor achievement for a low intelligence quotient group of high school boys, but correlations were insignificant for a high intelligence quotient group.

For the present purpose these findings are regarded as far from definitive. Whereas intelligence seems to contribute to performance of complex skills and to motor performance generally among low intelligent subjects, the suggestion is that it fails to differentiate performers of average or better intelligence at more simple skill levels. The literature reveals no research in which skill groups are compared. There is, then, no empirical support for hypotheses to be made with respect to these variables.

IV. THE CLOSURE FACTORS RELATED TO OTHER SIGNIFICANT VARIABLES

Possibly relevant are two investigations conducted by Carol Pemberton (1952a; 1952b). In an attempt to discover whether closure factors generalized to the affective and conative domains of personality, responses to Thurstone's interest schedule, the Allport-Vernon Study Of Values, Thurstone's temperament schedule, a self-rating inventory and an adjective checklist, indicated that

subjects with high scores for flexibility of closure regarded themselves as socially retiring, independent of the good opinion of others, analytical, and interested in theoretical and scientific problems. Subjects who made high scores on speed of closure regarded themselves as sociable, self-confident, quick to react and disinterested in theoretical problems. The similarity of these reports to the characteristics of the introverted-intuitive-thinking-judging constellation of Jungian types on the one hand, and to the extraverted-sensing-feeling-perceptive constellation on the other, is apparent.

The purpose of Pemberton's second study was to ascertain whether the same closure factors generalized to tasks requiring cognitive functions. Results showed that flexibility of closure was related to analytic thinking and speed of closure to synthetic reasoning though correlations were higher ($r = .81$ and $.72$) in the instance of flexibility of closure than in the case of speed of closure ($r = .58$ and $.53$).

The suggestion that perceptual closure generalizes across sensory modalities is made by White (1954) who found that measures of flexibility of closure in visual and auditory were significantly correlated with r 's

ranging from .54 to .66. He concluded that flexibility of closure may be central trait in a wide variety of behavior.

Studies reviewed lead to the conclusion that among perceptual variables, speed and flexibility of closure are factors which have a range of correlates in the cognitive sphere, and of the two, flexibility of closure shows the more distinct relationship.

CHAPTER III

DEFINITIONS AND HYPOTHESES

Definitions

Terms to be used in this and subsequent chapters are defined as follows:

Skilled performance of a gross motor act is defined as the ability to bring about predetermined results with maximum certainty and minimum expenditure of time and effort (Knapp, 1963).

A complex open skill is defined as a learned gross motor sequence which is complex in the sense that critical stimuli are variant in time and space. Further, complexity refers to the selective nature of decision processes inherent in the performer's freedom to adapt responses to his strategic intent. Openness refers to the fact that critical stimuli emanate from two sources, namely the external environment and internal proprioceptive mechanisms (Poulton, 1960). The term complex open skill group will hereafter be used to refer to subjects who are members of intercollegiate tennis, badminton, and fencing teams.

A simple closed skill is defined as a learned gross motor sequence which is simple in the sense that critical stimuli are relatively low in variability and high in redundancy, and in the sense that efficient performance depends upon the relative invariance of response. Such a skill is closed in the sense that critical stimuli are predominantly proprioceptive with the exception of a minimal number of environmental stimuli which are totally invariant except within known limits of time. The term simple closed skill group will hereafter be used to refer to members of inter-collegiate teams who specialize in sprint running (distances up to 400 meters for men and 200 meters for women) and sprint swimming (distances up to 200 meters for both sexes), the term sprint implying the attempt to sustain maximum speed over the full distance involved.

Speed of closure is defined as a perceptual ability such that the individual succeeds in unifying an apparently disparate perceptual field into a single meaningful percept (French, 1963). Subsequently the designation Cs (closure speed) will be used to refer to this variable.

Flexibility of closure is defined as a perceptual ability such that the individual succeeds in keeping one or more definite configurations in mind and in identifying these within an embedded context presumed to pose distractions (French, 1963). This variable will subsequently be referred to as Cf (closure flexibility).

Fluid general intellectual ability is a construct arising from Spearman's theory of general ability and Thurstone's second order factor among Primary Mental Abilities. The fluid general ability factor emerges in situations free of cultural bias, in predominantly non-verbal situations, in speeded situations and in all kinds of performance involving adaptation to novel situations (Handbook for the Culture Fair Intelligence Test, 1959). Subsequently this variable will be referred to as "g."

Extraversion is defined as an enduring personality trait such that the individual centres attention upon externals; that is, upon the outer world of people and things (Myers, 1962, p. 57). This variable will subsequently be referred to as E.

Intraversion is defined as an enduring personality trait such that attention remains centred in the subject. The individual thinks, feels, and acts in ways which demonstrate his interest in the inner world of concepts and ideas (Myers, 1962, p. 57). Subsequently this variable will be referred to as I.

Sensation is defined as a stable personality trait characterized by the predominance of sensory mechanisms in regulating behavior. The individual relies on sensory processes by which he is made aware of things directly (Myers, 1962, p. 2). Subsequently this variable will be referred to as S.

Intuition is defined as a stable personality trait characterized by the predominance of unconscious integrative mechanisms in regulating behavior. The individual relies on ideas or associations which the unconscious attaches to external things perceived (Myers, 1962, p. 2). Subsequently this variable will be referred to as I.

Thinking refers to conceptual assessment of a kind which discriminates between true and false. As a personality trait, thinking refers to the predominance of objective over subjective judgment (Myers, 1962, p. 52). Subsequently this variable will be designated as T.

Feeling refers to a subjective process which attaches affective value to percepts and concepts. As a personality trait, feeling refers to predominance of subjective over objective judgment (Myers, 1962, p. 52). Subsequently this variable will be designated as F.

Judgment refers to a stable propensity for rapid arrival at conclusions based on information reaching the individual from environmental sources (Myers, 1962, p. 58). This variable will subsequently be designated as J.

Perception, in the Jungian sense, refers to a stable propensity of the individual to delay decisions until a maximal amount of information from environmental sources has been taken in and processed (Myers, 1962, p. 58). This variable will subsequently be referred to as P.

Hypotheses

Since empirical findings do not provide a basis for prediction of relationships among the variables defined, hypotheses will be stated in the null form. Alternative hypotheses specifying the direction of

relationships will be stated, with those providing for relationships of opposite directional nature unstated but implied.

1. Speed of closure and flexibility of closure are perceptual abilities equally manifest in complex open and simple closed skill groups.

(1a) The simple open skill group is higher in speed of closure than the complex open group.

(1b) The complex open skill group is higher in flexibility of closure than the simple closed skill group.

2. Fluid general intellectual ability is equally manifest in the complex open and simple closed skill groups.

(2a) The complex open skill group is higher in fluid general intellectual ability than the simple closed skill group.

3. Extraversion, intraversion, sensing, intuition, thinking, feeling, judging, and perception are persisting traits of personality organization whose strength is equally manifest in complex open and simple closed skill groups.

(3a) The complex open skill group is higher than the simple closed skill group in strength of intra-version, intuition, thinking, and perception.

(3b) The simple closed skill group is higher than the complex open skill group in strength of extra-version, sensing, feeling, and judging.

4. The proportion of members of the complex open skill group who may be classified, respectively, as intraverted, extraverted, sensing, intuitive, judging, or perceptive types is equally to the proportion of members of the simple closed skill group who may be similarly classified.

(4a) The proportion of members classified, respectively, as intraverted types, intuitive types, thinking types, and perceptive types is greater within the complex open skill group than within the simple closed skill group.

(4b) The proportion of members classified, respectively, as extraverted types, sensing types, feeling types, and judging types is greater within the simple open skill group than within the complex open skill group.

CHAPTER IV

PROCEDURE

THE SAMPLE

The sample was comprised of students who, with the exception of three individuals, were members of intercollegiate athletic teams at the University of Alberta during the 1964-65 session. Tennis, badminton, and fencing were selected as activities meeting the criteria of complex open skills while sprint running and sprint swimming represented simple closed skills. The total number of athletes named by team coaches as being participants in intercollegiate competition in these activities was fifty-six. At the suggestion of the fencing coach, three fencers were added who were described as equivalent in skill to the members of that team but had been excluded as a consequence of regulations limiting the team to four persons. Years of experience in intercollegiate competition was the final team selection criterion in the case of fencers, however since skill attainment was a more important variable for the purposes of the present study the writer felt justified in including these subjects in the sample.

Since eligibility regulations of the Western Canadian Intercollegiate Athletic Association (Western Canadian Intercollegiate Athletic Association, 1964) govern qualifications

such as student status, academic attainment, years of competition, and numerical team quotas, and since eligibility rules imposed by the equivalent central intercollegiate body in eastern Canada do not substantially differ from those of the Western Canadian Intercollegiate Athletic Association, it is assumed that the sample chosen represents a population of Canadian intercollegiate athletes who participate in activities named, and that findings of this study may be generalized to that population.

The potential sample comprised fifty-nine subjects: twenty-two swimmers (12 men and 10 women); thirteen sprint runners (9 men and 4 women); eight badminton players (4 men and 4 women); six tennis players (3 men and 3 women); and ten fencers (6 men and 4 women). The distribution of subjects who participated in the study was as follows:

TABLE I

DISTRIBUTION OF SUBJECTS ACCORDING TO TEAM
AND SEX FOR THE TOTAL SAMPLE

	Swimmers	Runners	Tennis Players	Badminton Players	Fencers	Totals
Men	11	6	2	4	4	27
Women	9	4	3	4	3	23
Totals	20	10	5	8	7	50

Subjects named by team coaches were contacted by letter (Appendix C) and asked to return an enclosed post-card indicating their willingness to participate in the study.

Attrition may be accounted for as follows: One female fencer declined participation on the grounds that she served a double function as team member and team coach. Four athletes returned cards indicating unwillingness to participate. These were not re-contacted. Returns were not received from eight athletes; of these, five were reached by telephone and agreed to participate, while three could not be reached and were dropped from the sample. Two athletes who initially agreed to take part did not keep appointments for testing and when subsequently contacted stated that they could not devote time involved.

Ten (5 men and 5 women) of a potential sample of eleven gymnasts also participated in the study, gymnastics having been classified as a simple open skill. Findings relative to this group were regarded as subsidiary and are discussed elsewhere (Appendix A). Exclusion of this group from the main body of the study was presumed justified on the grounds of a sample size which precluded generalization to a larger population.

II. RESEARCH DESIGN

Essential variables included:

1. Skill classification--complex, open, and simple closed.
2. Perceptual abilities--Cf and Cs. (See pages 23 and 24).
3. Fluid general intellectual ability--"g." (See page 24).
4. Personality traits--E, I, S, N, T, F, J, and P. (See pages 25 and 26).
5. Sex.

Discussion of possible vitiating variables and controls:

III. PHYSICAL FACTORS

Anatomical, physiological, and morphological characteristics were regarded as partial determinants of skill attainment; however, there seemed little unequivocal evidence (Cratty, 1964, p. 32) to suggest that significant relationships exist between these variables and those under investigation. Error, if any, from this source was not regarded as serious.

IV. SOCIAL FACTORS

Control of this variable was partially achieved by exclusion of team activities. Whereas the desire for social interaction may well influence decisions to participate in sports, at higher levels of competition, it was presumed that this factor operated approximately equally in relation to each of the individual sports selected, hence predisposed choice of one skill no more than another. Errors introduced were assumed to cancel.

V. EXPERIENCE

The relative importance of cognitive factors has been shown to fluctuate during early stages of learning (Kulcinski, 1945). It was assumed that athletes comprising the sample were sufficiently advanced in learning that stabilization had come about. To insure that none were in initial stages, subjects were questioned concerning their experience at the time of testing. It was ascertained that none had had less than two years of competitive experience at the interscholastic, inter-club, or intercollegiate levels. Relative homogeneity of experience was also insured by regulations of the Western Canadian Intercollegiate Athletic Association (Western Canadian Intercollegiate Athletic Association, 1964)

restricting eligibility for intercollegiate competition to a period not exceeding five academic years. It was also ascertained that none of the subjects held membership in teams that crossed the complex open-simple closed classification so far as individual sports were concerned. A number of subjects were or had been members of intercollegiate team sports groups. Confounding from this source was not regarded as serious.

VI. MOTIVATION

It was assumed that athletes who had attained positions on an intercollegiate team were highly motivated to perform to capacity, and that the sample was homogeneous in this respect. General motives might relate to typical cognitive strategies, hence might be reflected in perceptual and personality measures.

VII. EDUCATIONAL BACKGROUND

Sufficient homogeneity with respect to this variable should be assured. The instrument used to measure fluid general intellectual ability was deliberately chosen to minimize effects of differential educational experience, and eligibility rules of the Western Canadian Intercollegiate Athletic Association (Western Canadian Intercollegiate

Athletic Association, 1964) stipulating student status and academic standards further contributed to control.

VIII. SOCIOECONOMIC STATUS

While there may be a relationship between socioeconomic status and participation in certain kinds of sports activities, this seems more likely to occur in the case of non-university sponsored activities. Activities selected were chosen to minimize the effects, if any, of this relationship since personal cost to participants in terms of travel and equipment were deemed minimal and approximately equivalent for each of the teams concerned.

IX. SEX

Sex differences in each of the essential variables were explored by statistical methods. Since significance was in no instance obtained, this variable was excluded in the overall design. For the reader's information, results of statistical analysis are presented in Appendix B.

X. DESIGN

The master design provided for testing of significance of differences between complex open and simple closed skill groups in Cs, Cf, "g," E, I, S, N, T, F, J, and P.

XI. SELECTION OF INSTRUMENTS

It has been stated that the purpose of the present study was to investigate the relationship of non-specific cognitive variables to gross motor skill. The fundamental criterion for selection of tests was, then, that they should yield measures which reflected pervasive organizing characteristics of individuals in the cognitive sphere. A question which immediately occurred was whether cognitive factors operative in skilled motor performance could be inferred from scores on paper and pencil tests. Fleishman (1956) discusses this problem and suggests that contrary to the notion that motor skill are narrow in scope and highly task specific, evidence reveals a broad group of psychomotor factors which may account for performance in a wide variety of tasks. He concludes that these factors may be sampled by printed tests. If general psychomotor factors can be so measured, it seemed reasonable that

perceptual abilities, intellectual ability, and personality traits contributing to skill might similarly be sampled through response to verbal items, in the case of personality traits, and by solution of two-dimensional figural problems in the case of intelligence and perceptual variables. This assumption seems in no way contrary to the theoretical principles underlying test construction. In regard to perceptual measures, it might be argued that visual tests fail to tap perceptual processes which occur in other sensory modes. Evidence of cross-modal sensory transfer and generalization (Miller, 1962; Cratty, 1964) deny the seriousness of this objection.

Finally, although norming data were largely extraneous to the problem at hand, reliability of measures was judged to be of particular importance as were construct and predictive validity.

XII. THE CLOSURE FACTORS

Of all factors identified in his factorial analysis of perception, Thurstone (1944) regarded Closure I (Cs) and Closure II (Cf) as those most likely to transcend the immediate perceptual context in which they were identified. Their relation to motor skill is suggested by the fact

that Cs loaded fairly heavily on a single hand and Cf on a two hand co-ordination task. In addition to selecting factors which were minimally specific, an attempt was made to choose tests which bore as close a resemblance as possible to cognitive demands of complex open and simple closed skills. In order to deal with variant stimuli in situations offering response freedom, it was suggested that tendency to perseverate would reduce efficiency of response. Accordingly, in Gestalt terms, an existing gestalt must be broken up in order that another be formed. In terms of perceptual readiness, anticipation must function to facilitate response to cues in an altered display. The description of factor Cf and of the Hidden Figures, Hidden Patterns, and Copying tests which loaded heavily on this factor (French, 1963) appeared to match requirements.

In the case of skills which demand response to relatively invariant stimuli, it would seem that rapid perceptual acquisition of cues would be vital. Speed of perceptual closure seemed to describe this ability hence tests loading heavily on this factor; namely, Gestalt Competition and Concealed Words (French, 1963) were selected for use.

An admitted weakness of these perceptual tests is

that their recommended use is limited to factor analytic studies, hence neither their reliability nor their validity is reported (French, 1963). To partially remedy this lack it was regarded necessary to establish the presence of the defined factors in the current sample by factor analytic methods to be later described, and to take factor loadings into account in deriving scores.

XIII. INTELLIGENCE

Basic test selection criteria stipulated need for non-specific measures. Accordingly a measure purporting to be one of general intellectual ability was sought. In order to avoid contamination by verbal abilities a non-verbal test seemed essential. Also characteristics of the sample suggesting relative homogeneity in intelligence, made it desirable to choose an instrument which would maximize the variance of scores. Cattell's Culture Fair Test appeared to satisfy these conditions.

The Culture Fair Test is described as an instrument for measuring fluid general ability; that is, ability which has high hereditary determination and is prominent in speeded situations and in performance of all kinds requiring adaptability to new situations (R. B. Cattell and A. S. K. Cattell, 1959). Absence of contamination with

acquired abilities is claimed, together with relative constancy of measures over a considerable age span. Correlations with other culture-free tests appear satisfactory ranging from .53 to .97. Correlation coefficients of .56 and .85 with the Revised Stanford Binet; .73 with the Otis; .59 with the A.C.E. and .84 with the Wechler-Bellevue have been reported (Buros, 1959). A correlation of .36 as against .25 for the Stanford Binet is reported in connection with Stanford Achievement Test scores. The author recommends the test as particularly suitable for discrimination among university undergraduates and graduates. Transformation of raw scores to intelligence quotients is based on a standard deviation of twenty-four intelligence quotient points. Test-retest reliability is quoted as ranging from .84 to .94, with split half coefficients between .91 and .95 reported.

XIV. PERSONALITY

In locating an instrument for the measurement of personality variables it seemed desirable to select one constructed upon a firm theoretical base, preferably upon theory which had a perceptual orientation. Since empirical evidence suggested that intraversion-extraversion

was a dimension associated with perceptual abilities, a measure of these traits seemed desirable. Again non-specificity was a criterion which called for broad inclusive dimensions rather than a multiplicity of discrete scales. Further, an attempt was made to select an instrument which, in addition to meeting the above requirements, minimized sex differences and the effects of social desirability.

Despite criticisms which might be made of Jungian or any other typological theory, it is Jung's opinion that variation in human behavior is orderly, consistent, and determined by the way individuals perceive and judge (Jung, 1923). This view is fully consistent with the present position. According to Jung, perception involves the process of becoming aware of phenomena and judgment, the process of arriving at conclusions about what is perceived. If individuals differ systematically in what they perceive and in conclusions reached, this should be reflected in their reactions, interests, values, needs, and motives, including their responses to personality inventory responses. The veridicality of statements an individual makes about himself is irrelevant so long as empirical evidence supports the fact that certain response patterns have established behavioral correlates.

Correlations with other personality measures, with job performance, and with other behavioral ratings (Myers, 1962) suggested that the Myers-Briggs Type Indicator was at least satisfactory in the sense defined. Some limitation on implications derived from Indicator scores resulted from failure of the author to report re-test data relevant to its reliability. Reported split-half reliability coefficients seemed creditable ranging from .80 to .89 for college samples. To avoid bias from acquiescence or desirability, the Indicator employs forced choice items and an additional correction for social desirability is incorporated in scoring. Disadvantages of the forced choice technique are offset by instructions which allow the testee to omit response when he feels unable to choose between alternatives. Sex differences found on the Thinking-Feeling scale are corrected by differential scoring for this dimension.

XV. DATA COLLECTION

Two group testing sessions were arranged within one week with subjects asked to attend the one most convenient. For twelve of the sixty subjects who were unable to attend either session, subsequent sessions were arranged in the following week. Of these twelve

subjects three were tested individually, while groups of two, three, and four respectively were tested together. All testing was carried out in university classrooms under optimum conditions.

Tests were administered by the writer in strict accord with manual instructions. In the two large group sessions an assistant was present to distribute and collect papers and to check on the accuracy of timing. Administration of the battery of seven tests took approximately two hours, fluctuation resulting only from time taken for all subjects to complete the Myers-Briggs Type Indicator which was untimed. Order of administration was as follows:

1. Gestalt Completion
2. Culture Fair Test of Intelligence
3. Concealed Words
4. Hidden Figures
5. Myers-Briggs Type Indicator
6. Copying
7. Hidden Patterns

This order was arbitrarily chosen to minimize fatigue effects by the interspersing of tests judged to be of greater difficulty with those of less difficulty,

the criterion of difficulty being degree of speededness relative to complexity of task.

Scoring

Tests were hand scored in accord with manual instructions and all tests were independently re-scored by a paid assistant.

XVI. TREATMENT OF RAW SCORES

Speed and Flexibility of Closure

In order to confirm the presence of factors Cs and Cf in the sample, raw scores obtained from sixty subjects on the five closure instruments were subjected to factor analysis, by principle axis method extracting two factors, using 1.000s in the diagonal of the correlation matrix (Harman, 1960). Factor I was found to account for 42 per cent and Factor II for 21 per cent together accounting for 63 per cent of the total variance. A third factor accounting for 15 per cent of the variance was interpreted as a general closure factor. The fourth and fifth factors accounting for 12 per cent and 8 per cent of variance respectively could not be interpreted and may represent error.

An oblique transformation by hand was carried out through the centroids of factors (1, 2) and (3, 4, 5) (Harman, 1960, pp. 264-273). The oblique pattern obtained is shown below.

TABLE II
OBLIQUE FACTOR LOADINGS FOR PERCEPTUAL TESTS

Test	Cs	Cf
Gestalt Completion	.869	-.087
Concealed Words	.715	.087
Hidden Figures	.167	.770
Hidden Patterns	-.047	.832
Copying	-.121	.782

Since the variance of raw scores on Cs1 and Cs2 and on Cf1, Cf2, and Cf3 showed lack of homogeneity and since factor loadings indicated that some tests contributed more than others to the total variance for the factor concerned, it was decided that conversion to standard scores from which a composite score for each

factor could be computed, might entail some loss of information.

Accordingly, factor scores were computed by the method of least squares fit using the structure matrix of the oblique factors (Harman, 1960, pp. 338-348).

Culture Fair Test of Intelligence

Raw scores for this test were converted to deviation intelligence quotients ($\sigma = 24$ I.Q. points) according to research norm tables provided (R. B. Cattell and A. K. S. Cattell, 1959, p. 48).

Myers-Briggs Type Indicator

The author points out that conversion of raw scores to difference scores or to continuous scores entails loss of information and for purposes such as the present, advises against conversion (Myers, 1962, p. 12). Conventional means computed from continuous scores, confound frequency and strength of preference, consequently mean strength for each separate scale is more informative and was accordingly computed for the present data.

To obtain type classifications, raw scores for each trait were determined and the higher of each pair of opposites taken to indicate the subjects preference type.

CHAPTER V

ANALYSIS OF DATA AND STATEMENT OF RESULTS

I. STATISTICAL TREATMENT

The construction of instruments employed in this study provided for the assumption that measures derived were of interval nature. The author of the Myers-Briggs Type Indicator (Myers, 1962) describes the distribution of scores in the morning population as symmetrical and somewhat platykurtic while Cattell and Cattell (1959) claim normality of distribution in intelligence quotient scores for the Culture Fair Test. Since no data was available with respect to the distribution of factors Cs and Cf in the population, a chi square test of goodness of fit of observed to expected frequencies was applied to data from the present sample (Ferguson, 1959). The distribution of scores was not found to depart significantly from normality. For these reasons it was decided that the assumptions required for use of parametric statistical tests could be met.

For all comparisons an alpha level of .05 was arbitrarily stipulated for rejection of the null hypothesis.

Note: Whereas the data lent itself to discriminant function analysis, the absence of ambiguous trends in the results of present analysis suggests that a discriminant analysis would fail to provide a more definite clarification of relationship.

Since empirical evidence did not warrant predictions regarding the direction of differences, two-tailed tests were used in each case.

For statistical test of hypotheses relating to:

1. Sex differences in Cs, Cf, "g," E, I, S, N, T, F, J, and P. (Appendix C).

2. Between group differences in Cf and Cs.

(Page 27).

3. Between group differences in "g." (Page 27).

4. Between group differences in strength of E, I, S, N, T, F, J, and P. (Pages 27 and 28).

t tests of significance of difference between mean scores were employed following tests for homogeneity of variance in which no significant F ratios were obtained (Ferguson, 1959, p. 136).

For statistical test of hypotheses relating to:

1. Sex differences in proportion of subjects classified as E, I, S, N, T, F, J, and P types. (Appendix C).

2. Between group differences in proportion of subjects classified as E, I, S, N, T, F, J, and P types. (Page 28).

The chi square test of independence (Ferguson, 1959, p. 168) was used. Tabulation of results follows:

TABLE III

MEAN FACTOR SCORES IN SPEED OF CLOSURE AND
FLEXIBILITY OF CLOSURE FOR SIMPLE CLOSED
AND COMPLEX OPEN SKILL GROUPS

Skill Group	Cs	Cf
Simple Closed	51.03	48.29
Complex Open	48.20	48.77
Difference Between Groups	$t = 1.00$	$t = .16$

TABLE IV

MEAN INTELLIGENCE QUOTIENTS ON CATTELL CULTURE
FAIR TEST FOR SIMPLE CLOSED AND
COMPLEX OPEN SKILL GROUPS

Skill Group	Intelligence Quotients
Simple Closed	127.43
Complex Open	128.75
Difference Between Groups	$t = .27$

TABLE V
MEAN RAW SCORES IN PERSONALITY VARIABLES
FOR SIMPLE CLOSED AND COMPLEX
OPEN SKILL GROUPS

Personality Traits	Simple Closed Group	Complex Open Group	Values of t
Extraversion	16.03	11.00	3.16 [☆]
Intraversion	9.03	14.40	3.00 ^{☆☆}
Sensing	14.70	10.00	2.28 [☆]
Intuition	9.53	13.85	3.02 ^{☆☆}
Thinking	8.33	8.75	.26
Feeling	11.13	11.75	.16
Judgment	12.43	13.60	.58
Perception	13.96	13.95	.004

[☆] $p < .05$

^{☆☆} $p < .01$

TABLE VI

FREQUENCY OF PERSONALITY TYPE CLASSIFICATION IN
SIMPLE CLOSED AND COMPLEX OPEN SKILL GROUPS

Skill Group	Extraverted Types	Intraverted Types	Sensing Types	Intuitive Types	Thinking Types	Feeling Types	Judging Types	Perceptive Types
Simple Closed	21	7	18	12	7	13	14	14
Complex Open	9	13	7	13	12	18	10	10
Values of Chi Square	$\chi^2 = 7.47^{***}$	$\chi^2 = 4.08^{**}$	$\chi^2 = .42$	$\chi^2 = 0$				

$^{**} p < .05$

$^{***} p < .01$

SUMMARY OF RESULTS

I. COMPARISON OF GROUPS IN STRENGTH OF INTRAVERSION AND EXTRAVERSION

On the extraversion scale of the Myers-Briggs Type Indicator the mean raw score for the simple closed skill group was 16.03 as compared to a mean of 11.00 for the complex open skill group.

On the intraversion scale, the mean raw score for the complex open skill group was 14.40 as compared to a mean of 9.03 for the simple closed skill group.

These differences were in the direction hypothesized and both are significant at the one per cent level of confidence. Results compel rejection of null hypotheses and acceptance of research hypotheses (page 27) that the simple closed skill group is higher in extraversion than the complex open skill group and that the complex open skill group is higher in intraversion than the simple closed skill group.

II. COMPARISON OF GROUPS IN PROPORTION OF MEMBERS CLASSIFIED AS INTRAVERTED AND EXTRAVERTED TYPES

The ratio of extraverted to intraverted types in the simple closed group was 21:7 and in the complex open skill

group, 7:13. The difference in proportions is significant at the one per cent level of confidence, compelling rejection of null hypotheses and acceptance of research hypotheses (page 27) that the proportion of members classified as extraverted types is greater within the simple closed skill group than within the complex open skill group, and that the proportion of members classified as introverted types is greater within the complex open skill group than within the simple closed skill group.

III. COMPARISON OF GROUPS IN STRENGTH OF SENSING AND INTUITION

On the sensing scale of the Myers-Briggs Type Indicator the mean raw score for the simple closed skill group was 14.70 as compared to a mean of 10.00 for the complex open skill group.

On the intuition scale, the mean raw score for the complex open skill group was 13.85 as compared to a mean of 9.53 for the simple closed skill group.

These differences were in the direction hypothesized and are significant at the five per cent and one per cent levels of confidence respectively. Results compel rejection of null hypotheses and acceptance of research hypotheses (page 28) that the simple closed

skill group is higher in sensing than the complex open skill group, and that the complex open skill group is higher in intuition than the simple open skill group.

IV. COMPARISON OF GROUPS IN PROPORTION OF MEMBERS CLASSIFIED AS SENSING AND INTUITIVE TYPES

The ratio of sensing types to intuitive types in the simple closed skill group was 18:12 and in the complex open skill group, 7:13. The difference in proportions is significant at the five per cent level of confidence compelling rejection of null hypotheses and acceptance of research hypotheses (page 28) that the proportion of members classified as sensing types is greater within the simple closed skill group than within the complex open skill group, and that the proportion of members classified as intuitive types is greater within the complex open skill group than within the simple open skill group.

V. COMPARISON OF GROUPS IN THINKING, FEELING, JUDGMENT AND PERCEPTION

Table V (page 50) shows that differences between skill groups in strength of thinking, feeling, judgment, and perception are non-significant. Similarly there was

no significant difference between groups in the proportion of members classified, respectively, as thinking, feeling, judging, or perceptive types. These results warrant acceptance of null hypotheses (page 28) relating to these dimensions of personality organization.

VI. COMPARISON OF GROUPS IN FLUID GENERAL INTELLECTUAL ABILITY

On the Cattell Culture Fair Test of Intelligence the mean intelligence quotient for the complex open skill group was 128.75 as compared to 127.43 for the simple closed skill group. The difference is non-significant compelling acceptance of the null hypothesis (page 49) that fluid general intellectual ability is equally manifest in complex open and simple closed skill groups.

VII. COMPARISON OF GROUPS IN SPEED OF PERCEPTUAL CLOSURE

For tests of closure speed (page 49) the mean factor score for the simple closed skill group was 51.03 as compared to 48.20 for the complex open skill group. This difference is non-significant compelling acceptance of the null hypothesis (page 27) that speed of closure is

a perceptual ability equally manifest in complex open and simple closed skill groups.

VIII. COMPARISON OF GROUPS IN FLEXIBILITY OF PERCEPTUAL CLOSURE

For tests of flexibility of closure (see page 49) the mean factor score for the complex open skill group was 48.77 as compared to 48.29 for the simple closed skill group. The difference is non-significant compelling acceptance of the null hypothesis (page 27) that flexibility of closure is a perceptual ability equally manifest in complex open and simple closed skill groups.

CHAPTER VI

DISCUSSION AND CONCLUSIONS

Findings appeared to confirm a relationship between certain personality traits and highly skilled performance in two cognitively different types of gross motor activity. A personality syndrome characterized by orientation to external objects and dependence on sensory stimulation has been shown to differentiate athletes who have attained a high level of performance in skills which seem to require less in the way of cognitive mediation, from athletes who perform at a high level in activities of greater cognitive complexity. A non-significant trend toward more rapid perceptual closure on the part of the former group in accord with the emerging syndrome.

In contrast, athletes who perform with high success in activities characterized by greater cognitive demand were shown to be generally more subject centred and more dependent on cognitive mediational processes in their relations with the environment. A tendency toward slower perceptual closure on the part of these athletes in agreement with theoretical expectation.

Results indicate that flexibility of closure is a perceptual ability which does not differentiate athletes in the two major skill groups. Closer examination of the definition of this variable and particularly of the specific task requirement in the three instruments employed to derive measures of flexibility of closure, yield a possible explanation for this finding.

As defined and as measured, flexibility of closure implies the ability to hold in mind definite configurations in order to isolate these in a distracting field. If it is true that the experienced tennis player, badminton player or fencer anticipates the appearance of discrete stimulus cues each of which is associated with a limited range of discrete response alternatives, then flexibility of closure should contribute to successful performance. However, the variable nature of cues in terms of time, sequence, and character, together with their external source, compounds uncertainty and reduces anticipatory effectiveness. In other words, it is doubtful that the athlete does carry in mind a repertoire of well defined cues, or that he can do so when he must attend to the selection of responses. It might seem that at the highest levels of performance efficient cue categorization enables the athlete to depend on the benefits of anticipation to

a greater extent than he does on the adaptation of response. Possibly athletes comprising the present sample lack sufficient experience to have so categorized cues together with their associated probabilities of occurrence and hence depend primarily on adaptive response to stimuli as they emerge in the display sequence.

Another explanation for the failure of skill groups to be differentiated by this variable is suggested by consideration not only of the action of the performer, but also of the nature of the environmental field in which he performs. While it seems true that stimulus response matching is largely automatized in the case of the sprinter, during competition environmental "noise" emanating from spectators and the motion of other competitors constitutes a potential source of distraction. Conceivably, an efficient start and maintenance of an efficient motion sequence depends on ability to abstract the vital initiating stimulus and subsequent proprioceptive cues from other impinging stimuli. In these terms flexibility of closure may well contribute to successful performance in competitive sprinting.

A number of explanations may be offered for the failure of groups to be differentiated on the basis of

fluid general intellectual ability. First, we are reminded of the operation of selective factors which distinguish university students from the general population. Cattell and Cattell (1959) have demonstrated validity of their test for prediction of academic achievement, thus homogeneity of the variable in the sample selected reduces likelihood of differences. Secondly, Jung (1923) points out that individuals whose dominant personality dispositions differ, approach environmental problems in ways, that although variant, may be equally adaptive in certain kinds of situations. The same should apply to cognitive abilities generally. If athletes in the simple closed skill classification are dispositionally set to attend to attributes of external objects, they might be expected to benefit maximally from clues provided in a visual figural sequence; that is, to obtain maximum information on which to base response selection. This disposition, in combination with a tendency for rapid closure should facilitate anticipation of the response which would complete a relational sequence of the kind presented in Culture Fair Test items. While athletes in the complex open skill class depend to a greater extent on mediational processes which should facilitate perception of

relationships, a set to attend to response selection may carry an attendant disregard of information provided. In highly speeded situations any tendency toward over-mediation should have inhibiting effects. High speededness is clearly an attribute of the Cattell test.

The thinking-feeling personality dimension may, in actually bear little, if any, relation to motor performance and results suggest that this is the case. The subjective orientation of the complex open skill group suggests that members might be disposed to impose value judgments on what is perceived, yet Jung makes no claim that intraverbs or intuitive types are more inclined to do so than are extraverts or individuals with a sensory orientation. In any event, in performance of a practiced motor sequence associations giving rise to affect might be expected to derive from experiences of success or failure in either cue categorization or response outcome, and so might serve a reinforcing or an infirming function which would ultimately facilitate adaptive response. Similarly, an objective attitude might facilitate performance in either skill class. Despite their subjective orientation athletes comprising the complex open skill group cannot be presumed to distort perception of external objects.

Where they might be inclined to place a personal construction upon more abstract events, in dealing with concrete phenomena, the probability of distortion through subjective evaluation may be viewed as minimal.

The greater disposition of females toward a feeling orientation is reflected in the data and although it does not reach significance in the present analysis, sex may well be a confounding variable in thinking-feeling comparisons.

It is somewhat more difficult to account for lack of differences between groups in judgment and perception. This dimension is not one proposed by Jung, and Myers (1962) fails to specify its theoretical origin. Perception and judgment are, according to Myers, preferred ways of dealing with the environment. Where perception is the dominant process the individual attends to externals but is slow to close upon a single solution. Possibly what this description implies is not so much sharpened sensory awareness as excessive conscious mediation. While the individual whose dominant process is judgmental is described as being inclined to disregard relevant cues, he tends to close rapidly. In the context of the present theory these descriptions pose a

contradiction. Without denying that such combinations of traits exist in individuals, it may be safe to say that where sensory awareness and response speed are both important determinants of performance as they are in motor skill, the judgment-perception dimension is simply task irrelevant.

CHAPTER VII

IMPLICATIONS

I. IMPLICATIONS FOR THEORY

It has been proposed that Gestalt theory was formulated out of protest toward the preoccupation of behaviorists and psychophysicists with measurable aspects of behavior and physiological concepts. The relation between various perceptual qualities identified by Gestalt psychologists and efficient motor performance has been little explored. The present study and other recent investigations (Kreiger, 1962) suggest that analysis of skilled motor acts must take into account the nature of the performer's total perceptual field together with stable personality tendencies related to perception of central figures. Goldstein (1939) fundamentally maintained that the ease with which objects were extracted from their environmental surrounds determined the consistency with which certain motor tasks could be performed. Moreover, Goldstein concluded that perception of figure-ground relations was associated with sensory thresholds for various kinds of stimuli and with personality traits. Results of the present study neither confirm nor deny

this position, however, the demonstrated relationship between motor skill and personality in main comparisons together with tentative findings in a subsidiary investigation of gymnasts (Appendix A) indicates that further exploration of perceptual abilities as determinants of skill might be profitable. Among perceptual attitudes which might be investigated are Klein's levelling-sharpening and focusing-nonfocusing tendencies (Klein, 1949). The limitation of Gestalt theory as a framework for the study of motor behavior lies in its concern with environmental phenomena, particularly visual fields, to the exclusion of proprioceptive source of stimuli. Sensory-tonic theory on the other hand, emphasizes the interaction of sensory and tonic factors in perception and the theory of facilitating set upon which the present investigation was based clearly allows for such interaction.

Closely related are theories of motivation which have a perceptual basis. If a motive may be regarded as an intervening variable interposed between sensory input and motor output, then the concept of perceptual readiness is closely related to what Hebb (1961) calls set; a term which he regards as synonymous with motive.

In either case, discovery of relationships between personality and motor skill together with tentative conclusions regarding the importance of perceptual abilities in skilled performance brings to light the possibility that the interest needed to direct individuals toward certain kinds of athletic endeavor and to sustain their participation in practice as well as competitive situations has at least a partial basis in motives allied to attitudinal and perceptual set. The present study has been concerned with determinants of motor performance, but seems to carry some implications for theories of interest development.

Negative findings with respect to perceptual variables and general intellectual ability may be explained in a framework of psychological information theory as developed by Bruner (1957). If, as Bruner proposes, perceptual experience is the end product of a process of categorization of cues, and if, as he also states, stable categories may be explained in the neuro-physiological terms employed by Hebb, then present findings which support hypothesized relationships also may be regarded as generally supporting to his theoretical position and more particularly to his concept of perceptual readiness.

Explicitly, if athletes who are highly skilled in

complex open activities depend more on mediating processes than do athletes who have a sensory orientation and are more stimulus-bound, then in Bruner's terms veridicality of cue categorization and the ability to permit hypotheses about what is to be perceptually encountered to be informed by sensory input, is more important to the former group than to the latter. Conclusions are also in accord with Bruner's notion that over-mediation in speeded situations reduces readiness to respond to sequential stimuli, and here proprioceptive stimuli deserve equal consideration with stimuli from external sources.

Turning to the problem of motor learning which Cratty (1964, p. 215) has defined as stable change in level of skill as a result of repeated trials, it becomes evident that performance is simply a criterion of learning. Viewed as such performance implies learning, and as a consequence of present findings, it should be possible to state that a subject centered intuitive disposition facilitates learning of complex open skills while an object centered sensory orientation enhances learning of simple closed skills. This statement must necessarily be qualified in view of the changing factor structure of skills with practice (Fleishman and Hempel, 1954). Whether attitudinal dispositions contribute

differentially at various stages of learning is, at present, a matter for speculation. Also worthy of consideration is the possibility that personality factors are of greater importance in adult motor learning than they are in the motor learning of children in whom personality organization may be regarded as less stable.

II. IMPLICATIONS FOR RESEARCH

In future studies, the analysis of skills with regard to their stimulus, mediational, and response demand properties is recommended. Additionally, a more precise skill classification system should take into account properties of the total environment from which stimulus cues must be extracted.

Possible theoretical approaches to the problem are several with information theory and perceptual-motor set theory being perhaps the most promising.

Initially, it seems essential to determine whether good or poor performers in defined skill classes may be differentiated by personality and perceptual measures. Age of subjects and stage of learning are variables which might subsequently be introduced. If hypothesized relationships hold, it might be of interest to determine

stress effects as reflected by performance of high extra-verted subjects in novel motor tasks of high cognitive complexity as it might be to assess performance of intra-verted subjects in novel tasks which were highly speeded and redundant. Studies of this kind might have particular relevance for industrial placement.

III. IMPLICATIONS FOR EDUCATION

Essentially, the present study draws attention to a matter largely disregarded by researchers in physical education; namely. that because central neural mechanisms are involved in all motor acts which may be termed skills and because certain skills impose greater cognitive demands than others, relatively stable cognitive abilities and dispositions may be expected to combine with physical factors to determine levels of skill attainment. Clearly this consideration is of major relevance to motor learning and performance prediction problems. While it might be claimed that cognitive factors are irrelevant to performance of simple skills, the question of the inhibiting effects of over-mediation is one which might be investigated.

Once relationships between cognitive variables

and motor performance have been established it remains for researchers to attempt clarification of causal relations for it is such knowledge that will carry greatest meaning for educational practice. At the present time there is no evidence to preclude the possibility that repeated practice of certain forms of gross motor activity produces attentional sets which may generalize to become stable dispositions. Piaget (Flavell, 1963) has drawn attention to the salience of sensorimotor experience in the development of intellectual structures in infancy and early childhood. He has further speculated that major structural reorganizations come about at critical periods extending to adolescence and that prior to this movement through space and manipulation of concrete objects substantially facilitates attainment of mathematical and verbal concepts. The discovery of association between personality traits and success in certain kinds of motor activity among young adults leads to speculation about the origins of their personality structure. It seems not inconceivable that among genetic and environmental influences early motor experiences hold some degree of significance.

If stable perceptual sets and personality traits

facilitate varying forms of motor endeavor, it may be concluded that such variables should be taken into account in the diagnosis and remediation of motor learning difficulties. The implication extends beyond formal gymnasium instruction, since at certain periods in childhood and adolescence athletic prowess is closely associated with peer acceptance and hence with social adjustment and self esteem (Jones, 1946). Failure on the part of teachers to recognize that non-physical characteristics may contribute to inability and disinterest in athletic pursuits carries potentially deleterious consequences for children whose motor accomplishment is unreasonably expected to match their physical capacity.

Finally, conclusions resulting from the present research would seem to hold implications for the theory and practice of play therapy. If pathological tendencies are reflected in perceptual distortion or over-attention to particular sources of stimuli, then play activities which demand re-direction of attention might have therapeutic effects.

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A P P E N D I X A

THE GYMNASTICS GROUP

The writer's decision to exclude discussion of the simple closed skill group from the main body of the text stemmed solely from the opinion that generalizations were unwarranted on the basis of responses of ten subjects. The findings, however, merit reporting in view of certain relationships which emerged and may be of some interest to the reader.

Gymnasts were full participants in the study and were in no way distinguished from other subjects in sampling or in administration of the test battery. In order to obtain comparative data which included this group, it was necessary to undertake a second statistical analysis based on a total N of 60. Non-parametric methods were used exclusively since differences in the Ns for skill groups accounted for significant F ratios in most cases. The Mann-Whitney U test of significance of difference by rank for two independent samples (Siegel, 1956, p. 116) was used for testing of hypotheses relating to differences in Cf, Cs, and "g," while the chi square test of association (Ferguson, 1959, p. 169) was used for testing hypotheses relating to differences in proportions of members classified as particular personality types.

In the null form, the following statistical hypotheses were tested:

1. Ho: Flexibility of closure is a perceptual ability equally manifest in simple open and complex open skill groups.

2. Ho: Flexibility of closure is a perceptual ability equally manifest in simple open and simple closed skill groups.

3. Ho: Speed of closure is a perceptual ability equally manifest in simple open and complex open skill groups.

4. Ho: Speed of closure is a perceptual ability equally manifest in simple open and simple closed skill groups.

5. Ho: Fluid general intellectual ability is equally manifest in simple open and complex open skill groups.

6. Ho: Fluid general intellectual ability is equally manifest in simple open and simple closed skill groups.

7. Ho: The proportion of members of simple open skill groups who may be classified, respectively, as extraverted, intraverted, sensing, intuitive, thinking,

feeling, judging, or perceptive types is equal to the proportion of members of complex open skill groups who may be similarly classified.

8. Ho: The proportion of members of simple open skill groups who may be classified, respectively, as extraverted, introverted, sensing, intuitive, thinking, feeling, judging, or perceptive types is equal to the proportion of members of simple closed skill groups who may be similarly classified.

Tabulation of results follows:

TABLE A

VALUES OF Z ASSOCIATED WITH ACCEPTANCE OF
THE NULL HYPOTHESIS FOR COMPARISON OF
SKILL GROUPS IN FLEXIBILITY
OF CLOSURE

	Simple Open Skill Group
Simple Closed Skill Group	2.81 ^{***}
Complex Open Skill Group	2.07 ^{**}

^{*}p < .05
^{**}p < .01

TABLE B

VALUES OF Z ASSOCIATED WITH ACCEPTANCE OF
THE NULL HYPOTHESIS FOR COMPARISON OF
SKILL GROUPS IN SPEED OF CLOSURE

	Simple Open Skill Group
Simple Closed Skill Group	.10
Complex Open Skill Group	.79

TABLE C

VALUES OF Z ASSOCIATED WITH ACCEPTANCE OF
THE NULL HYPOTHESIS FOR COMPARISON OF
SKILL GROUPS IN INTELLIGENCE QUOTIENT

	Simple Open Skill Group
Simple Closed Skill Group	1.91
Complex Open Skill Group	.73

TABLE D
FREQUENCY OF PERSONALITY TYPE CLASSIFICATIONS IN
SIMPLE OPEN AND SIMPLE CLOSED SKILL GROUPS

Skill Group	Extra- verted Types	Intra- verted Types	Sensing Intuitive Types	Thinking Feeling Types	Judging Perceptive Types
Simple Open	7	3	6	5	5
Simple Closed	21	9	12	18	14
Values of Chi Square	$\chi^2 = .15$	$\chi^2 = 0$	$\chi^2 = .03$	$\chi^2 = 0$	$\chi^2 = 0$

TABLE E
FREQUENCY OF PERSONALITY TYPE CLASSIFICATIONS IN
SIMPLE OPEN AND COMPLEX OPEN SKILL GROUPS

Skill Group	Extra- verted Types	Intra- verted Types	Sensing Intuitive Types	Thinking Feeling Types	Judging Perceptive Types
Simple Open	7	3	6	5	5
Complex Open	7	13	7	13	10
Values of Chi Square	$\chi^2 = 4.83^*$		$\chi^2 = 2.86$	$\chi^2 = 1.40$	$\chi^2 = 0$

* $p < .05$

CONCLUSIONS AND DISCUSSION

It was tentatively concluded that gymnasts were significantly higher than both the tennis-badminton-fencing group and the sprint runner-swimmer group in flexibility of closure. There was a trend toward higher fluid general intellectual ability in the gymnast group as compared to other groups. Gymnasts were tentatively concluded to be higher in extraversion and lower in intraversion than members of the complex open skill group. In traits of extraversion, intraversion, sensing, intuition, thinking, and feeling the gymnasts more closely resembled the simple closed skill group than did the complex open skill group.

Analysis of the perceptual task in tests of flexibility of closure reveals a similarity between that task and perceptual motor tasks involved in performance of gymnastic activities. In these tests a figural model is presented which must be retained so that it may subsequently be isolated in a distracting field. Presumably, prior to the initiation of a sequential movement sequence, the gymnast, to whom precision is vital, retains an image,

not necessarily visual, of the movement sequence to be performed. Although essential aspects of the external display are in most instances stable and known in advance as in free exercise or fixed apparatus skills, the fact that movement is variant temporally and ranges greatly within a three-dimensional spatial context, raises a question as to whether vestibular and kinesthetic sources of sensory feedback potentially constitute what might be regarded as distractions. Perceived dissonance between movement image and feedback impressions may be thought of in this sense. The need to attain equilibrium relates then, not only to articulation between performer and apparatus, but also between conceived and actual performance, both of which are achieved by amendment of motion. In printed tasks purporting to measure flexibility of closure, the subject has no prior knowledge of contextual distractions to be encountered except as practice somewhat narrows the range of expectancy. Similarly, the gymnast has little fore-knowledge of events which will make amendment necessary. The relationship is highly speculative but suggests further investigation based on adequate Ns.

In full recognition of the fact that chance may have accounted for the near significance of difference

between gymnasts and other groups in intelligence quotient, evidence linking flexibility of closure with intellectual measures (Elliot, 1961) justifies discussion of the present findings. Barrat (1962) maintains that the nearer test authors approach achieving a culture-free measure of intelligence, the more the total variance of the test will reflect basic neuro-physiological processes involved in sensory-motor input systems. Partial substantiation is offered by his finding that scores on the Cattell Culture Fair Test correlated significantly ($p < .01$ $r = .43$) with critical flicker frequency. Somewhat broader implications are suggested by the fact that the writer obtained a significant correlation ($\rho = .64$) between Cattell intelligence quotients and factor scores for flexibility of closure for the full sample of sixty subjects. Whether this relationship was influenced by other variables, for example spatial ability, which might distinguish athletes from the general population; whether performance on flexibility of closure tasks reflects a basic ability to perceive relationships, or whether the Cattell test really measures a specific perceptual ability, are all questions which remain to be resolved.

A P P E N D I X B

TABLE F

MEAN FACTOR SCORES FOR MALE AND FEMALE SUBJECTS IN
SPEED OF CLOSURE AND FLEXIBILITY OF CLOSURE

N = 60

Sex	Cs	Cf
Male	52.01	49.38
Female	47.41	47.43
t = 1.60		t = .67

TABLE G

MEAN INTELLIGENCE QUOTIENTS FOR MALE AND FEMALE
SUBJECTS ON THE CATTELL CULTURE FAIR TEST

N = 60

Sex	Intelligence Quotient
Male	128.29
Female	127.56
t = .16	

TABLE H
MEAN RAW SCORES IN PERSONALITY VARIABLES
FOR MALE AND FEMALE SUBJECTS
N = 60

Personality traits	Male	Female	t
Extraversion	13.77	14.30	.29
Intraversion	11.55	10.56	.49
Sensing	12.62	13.04	.19
Intuition	12.29	10.04	1.38
Thinking	9.70	7.13	1.06
Feeling	9.92	13.08	1.52
Judgment	13.66	14.40	.67
Perception	12.88	14.86	.90

TABLE I
FREQUENCY OF PERSONALITY TYPE CLASSIFICATIONS
FOR MALE AND FEMALE SUBJECTS
N = 50

Sex	Extraversion	Intraversion	Sensing	Intuition	Thinking	Feeling	Judgment	Perception
Male	16	11	12	15	13	14	14	12
Female	14	9	13	10	6	17	10	12
Values of Chi Square	$\chi^2 = .16$	$\chi^2 = 2.04$	$\chi^2 = 2.94$	$\chi^2 = .08$				

A P P E N D I X C

A copy of the letter employed to solicit participation of subjects in the present research is to be found on the following page.

9109 - 112th Street,
Edmonton, Alberta,

Dear

I wonder if I could enlist your help in a research project which I feel may be of considerable interest to persons working in the field of physical education and to skilled athletes such as yourself.

I am a physical education graduate currently pursuing a master's program in educational psychology. My own experience suggests that certain psychological variables relate to success in selected forms of athletic endeavor and a small body of research tends to bear this out. In order to clarify and extend knowledge concerning the possible relationships involved, I wish to administer a battery of paper and pencil tests to a group of athletes who have demonstrated superior skill, as evidenced by the fact that they have been chosen to represent the University of Alberta in intercollegiate competition. As you will appreciate, the number of students who fall in this category is relatively small. It is for this reason that I must request and do hope to obtain the co-operation of each man and woman who is presently or was last year a member of one of the teams I have selected to participate in the study.

The time involved will be one two-hour session. Testing will be conducted on a group basis, data will be analyzed by groups, and at no time will individual performance be known to anyone but the experimenter. The tests themselves contain no academic material and are substantially geared to the measurement of perceptual variables. Some, by virtue of their novelty, you may find quite interesting to do. For those who wish to know them, findings will be made available at the conclusion of the study.

For the convenience of participants, two testing sessions have been arranged. These are on:

If you are willing to take part in this research, will you select the session you prefer and indicate this, together with additional information requested, on the enclosed postcard? Please mail this card as soon as you can — in any event, before . Your help is sincerely requested and will be most gratefully received.

Yours very truly,

(Miss) Mary H. Richardson.

This research project has the approval of Dr. M. Gulutsan, Thesis chairman, and Dr. C. C. Anderson, both of the Department of Educational Psychology, and Dr. M. Howell of the Faculty of Physical Education.

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